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FORESTRY IN DENMARK

A GUIDE TO FOREIGNERS

BY

AXEL S. SABROE

PUBLISHED BY
THE DANISH FOREST SOCIETY

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JOSEPH SAXE

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Directorate for State Forestry, Slotsholmen, Kjøbh. K.
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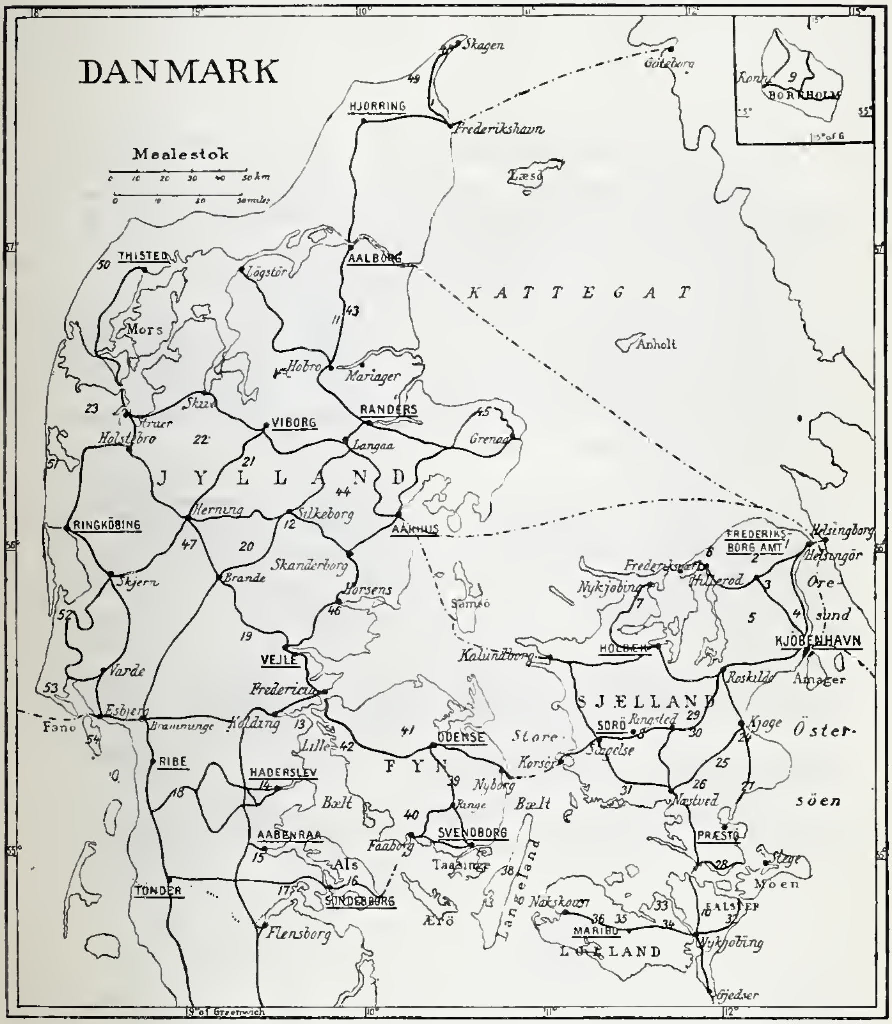
Danish Experimental Forestry Service, Møllevangen, pr. Springforbi.
Royal Veterinary and Agricultural College, Bülowsvej, Kjøbh. V.
Commission for the Instruction of Rangers, Arresødal pr. Frederiksværk.
Government Seed Control, Fjords Allé 15, Kjøbh. V.
Geological Survey of Denmark, Gl. Mønt 12 & 14, Kjøbh. K.
Statistical Department, Kristiansgade 2, Kjøbh. K.
Meteorological Institute, Toldbodvej 15—19, Kjøbh. K.
Danish Forest Society, Secretary and Editor, Brogade 3. Kjøbh. C.
Association of wooded and landed Proprietors in Denmark. Købmagergade 11^2, Kjobh. K.
Danish Heath Society, head-office, Viborg.
Association of Employers for Agri- & Silviculture in Denmark, Nørre Farimagsgade 33, Kjøbh. K.
Association of Danish graduate Foresters, Brogade 3, Kjøbh. C.
Association of public Superintendents etc., Rømersdal, Bornholm.

Letters to foresters may be addressed to the Secretary of the Danish Forest Society, who will forward same.

General map giving names of counties (underlined), principal railways, and forest districts: Public forests: 1 »Kronborg« and »Gurre«; 2 »Maarum«, »Esrom« and »Nøddebo« (»Grib Skov«); 3 »1st Frederiksborg« and »Hørsholm«; 4 »1st Kjöbh.« and »Deer-park etc.«; 5 »2nd Kjöbh.« and »2nd Frederiksborg«; 6 »Tisvilde-Frederiksværk«; 7 »Odsherred«; 8 »Sorø Academy 1st and 2nd«; 9 »Bornholm«; 10 »Falster«; 11 »Buderupholm«; 12 »Silkeborg«; 13 »Stenderup«; 14 »Haderslev«; 15 »Aabenraa«; 16 »Sønderborg«; 17 »Graasten«; 18 »Lindet«; 19 »Randbol«; 20 »Palsgaard«; 21 »Viborg« (»Stendalgaard« etc.); 22 »Feldborg«; 23 »Klosterheden« (18-23 are heath districts). — Private forests mostly referred to: 24 »Vallø«; 25 »Bregentved«; 26 »Gisselfeld«; 27 »Vemmetofte«; 28 »Petersgaard«; 29 »Svenstrup«; 30 »Giesegaard«; 31 »Holsteinborg«; 32 »Corselitze«; 33 »Oreby«; 34 »Hardenberg«; 35 »Knuthenborg«; 36 »Christianssæde«; 37 »Pederstrup«; 38 »Langeland«; 39 »Ravnholt«; 40 »Brahetrolleborg«; 41 »Langensø«; 42 »Wedellsborg«; 43 »Lindenborg«, »Nørlund« and »Villestrup« (»Rold Skov«); 44 »Frijsenborg«; 45 »Benzon« and »Meilgaard«; 46 »Boller«; 47 »Birkebæk« (DHS main plantation). — Dune-plantations: 48 »Skagen«; 49 »Tversted«; 50 »V. Thorup«; 51 »Husby«; 52 »Nyminde«; 53 »Bording«; 54 »Fano«.


DANMARK
Maalestok
0 10 20 30 40 50 km
0 10 20 30 miles
Skagen
Göteborg
HJORRING
Frederikshavn
Læsö
BORNHOLM
Rønne
9
THISTED
Mors
Lögstör
AALBORG
KATTEGAT
Anholt
Hobro
Mariager
Skive
Struer
Holstebro
VIBORG
RANDERS
Langaa
Grenaa
JYLLAND
RINGKÖBING
Herning
Silkeborg
AARHUS
Skjern
Brande
Skanderborg
Horsens
Samsö
VEJLE
Varde
Fredericia
Esbjerg
Fanö
Bramminge
Kolding
RIBE
HADERSLEV
Lille Bælt
FYN
ODENSE
Nyborg
Store Bælt
Korsör
Ringe
SVENDBORG
Faaborg
AABENRAA
Als
Taasinge
TÖNDER
SÖNDERBORG
Flensborg
Ærö
Langeland
Nakskov
MARIBO
LOLLAND
FALSTER
Nykjöbing
Gjedser
Möen
Stege
PRÆSTÖ
Næstved
Kjöge
Östersöen
SJÆLLAND
SORÖ
Ringsted
Slagelse
Kalundborg
HOLBÆK
Roskilde
KJÖBENHAVN
Amager
Öresund
Helsingör
Helsingborg
FREDERIKSBORG AMT
Hillerød
Frederiksværk
Nykjöbing
9° of Greenwich
10°
11°
12°
15°
55°
56°
57°

OLD DANISH MEASURES AND WEIGHTS.

On April 1st 1912 the metric system became official; before that time the following designations were used:

1 Alen = 2 Fod = 24 Tommer = 0.6277 meter (m)
1 Fod (F.) .... = 0.3138535 »
1 løb. Favn (Fv.) = 3 Alen.. = 1.8831 »
1 Mil = 12 000 Alen......... = 7.5325 kilometer (km)
1 Kvadratfod .... = 0.0985 square meter (m^2)
1 Tønde Land (Td. L.) ..... = 0.5516 hectare (ha)
1 Kubikfod (Kbf.) .... = 0.0309 cubic meter (m^3)
1 Favn Skovmaal (Fv.) à 80 Kbf. .... = 2.4733 Rummeter (rm)
1 Korntønde (Td.) .... = 1.3912 hectoliter (hl)
1 Pund (℔) = 100 Kvint .... = 0.5000 kilogram (kg)
1 løb. Fv. pr. Td. L. .... = 3.4138 m per ha
100 Kvadratfod pr. Td. L. .... = 17.857 m^2 per ha
100 Kbf. pr. Td. L............. = 5.6045 m^3 » »
1 Td. » » » .... = 2.5220 hl. per ha

When in Danish yield-tables the diameter is referred to, it is generally the diam. of mean basal area

$$= 2\sqrt{\Sigma \text{ basal area : stem cipher} \times \pi}.$$

The diameter of standing trees is taken 1.3 m from the ground.

The unit of coinage is 1 Krone (Kr.) = 100 Øre. At par, 1000 Kr. = £ 55.068 = $ 267.99 = Fr. 1388.89 = M. 1125.

GEOGRAPHY, SOIL, AND CLIMATE.

Geography: The area of Denmark is 43 017 km^2, situated chiefly between 54° 34′ and 57° 45′ N. lat., and 8° 5′ and 12° 47′ E. long. (from Greenwich). In the Baltic lies the island of Bornholm, about 130 km from the nearest point of the rest of the country. Towards the east there are several good ports, but only one by the North Sea. See map in front.

Most of the country is hilly or undulated, reaching its greatest height (172 m above sea-level) in Central-Jylland. West of this ridge there are large heaths, and along the North Sea, a belt of dunes which, towards the south, merge into marshlands. In Lolland and Falster, too, there are low-lying tracts sheltered by dikes. Rocks are found in Bornholm only.

The population is distributed as follows (1924):

The capital, Kjøbenhavn with suburbs	728 105	inhabitants	21 %
7 towns exceeding 20 000 inhabitants	266 564	—	8 —
The remaining towns	472 919	—	14 —
The country districts	1 918 686	—	57 —
Total	3 386 274	inhabitants	100 %

The country population proper comprises about 45 %. The density of population for the whole country is 7872 inhabitants per 100 km^2, for the counties of Sjælland (excluding Kjøbenhavn): 7854, for the counties of Fyn: 9858, and for Jylland:

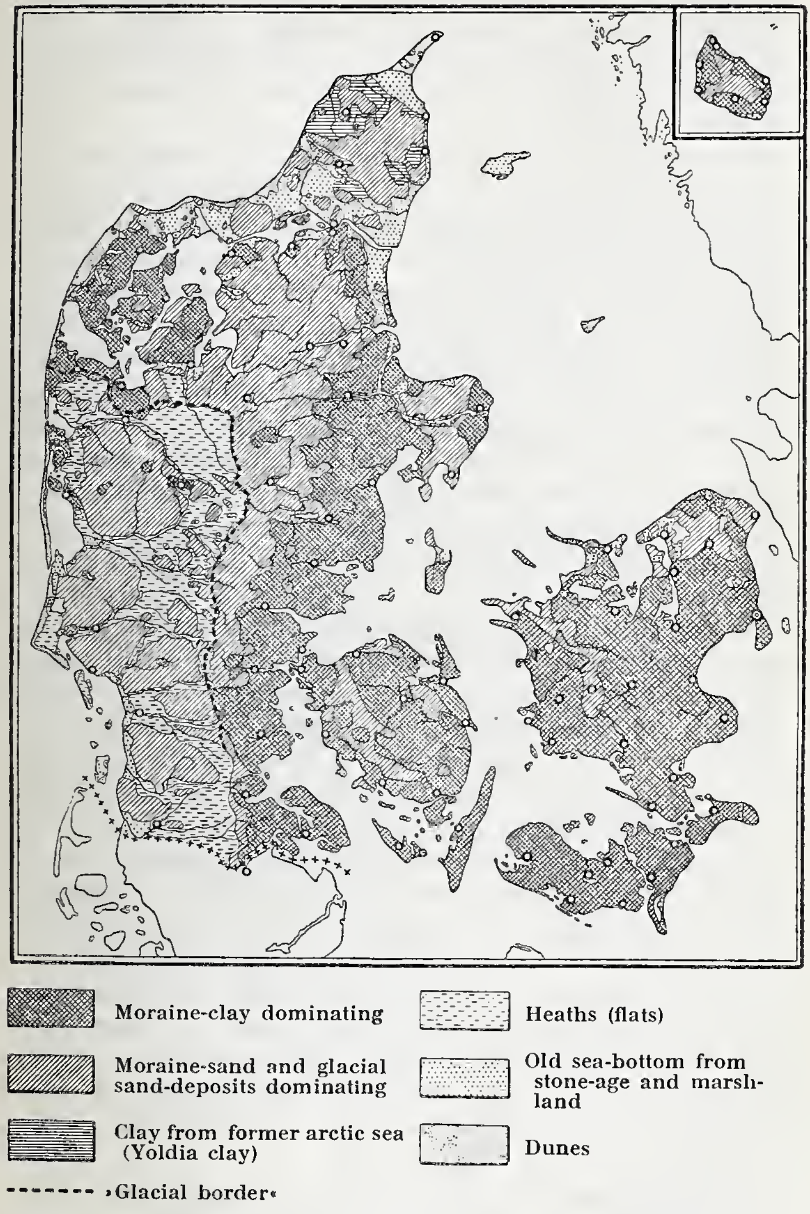
5246. Lowest is the county of Tønder (S.W. Jylland): 2743, and the county of Ringkjøbing (W. Jylland): 3901.

Geology: In Bornholm we meet with granite, frequently laid bare, or else covered with strata from the glacial period. In some places we find slate and sandstone (Nexøsandsten) from the Cambrian, and coal of an inferior quality from the Jurassic.

The substratum of the rest of the country is the so-called »Skrivekridt«, common chalk, formed during the Cretaceous from lime-shells deposited in the sea once covering the site of the country. So far it has proved impossible to get through this huge layer, projecting in some places above the surface, as e. g. at Møens Klint (138 m), and near Aalborg where it constitutes the basis of Cement-making. A later formation is the coral-rag (Faxekalk) in S. Sjælland (large lime-quarry). During the glacial periods the country was several times covered with ice, and bottom- and terminal moraines consisting of materials from the Norwegian and Swedish mountains were deposited. During the last glacial period the ice came to a stop in Jylland, forming the Mid-Jylland ridge, while to the west of this »glacial border« the plains of heathy country were formed by sand deposited by the melting ice. The hilly parts of the heath, on the other hand, are generally ascribed to formations during an earlier glacial period (see map p. 9).

Later on, the country underwent a number of elevations and depressions, and large peat-bogs were formed from turf-moss (especially in Jylland). The small bogs in the old forests show the following successive growths after the glacial period: tundra; birch and asp; pine; oak and beech.

Forest-soils: As shown on the map, the forests of most of the islands and of E. Jylland have more or less clayey soil. In E. Sjælland S. of Kjøge and


Moraine-clay dominating
Moraine-sand and glacial sand-deposits dominating
Clay from former arctic sea (Yoldia clay)
›Glacial border‹
Heaths (flats)
Old sea-bottom from stone-age and marsh-land
Dunes

in Lolland the clay is very tough, and draining difficult owing to deficient sloping. In some parts of N. Sjælland, W. Fyn, and especially Central-Jylland, the forest soil is sandy (as to heaths, see p. 38).

The forest-soil has especially been examined by P. E. Müller 40—50 years ago. The good mould, the characteristic plants of which are Anemone, Asperula odorata, etc., is found in the sheltered and carefully tended forests. If earthworms and bacteria are unable to live there, e. g. on account of hard or dry soil, caused by the wind, sheddings accumulate, and raw humus, accompanied by layers of grey heathy sand and of red earth, is formed; raw humus generally appears under beech and spruce in loose, sandy soil. The characteristic plants for raw beech humus are Convallaria majalis, Majanthenum bifolium, Trientalis europæa and in the poorest soil, moreover, Vaccinium Myrtillus and Calluna vulgaris. — The exsiccation by the wind will often do great damage to the soil near the outskirts and in large cultivated areas, even though no raw humus be formed. — Sporadically there are small and damp hollows with mouldy soil, and only in some forest parts do we meet with moory tracts unsuitable for cultivation.

The Climate is mostly insular, cold-temperate, with mild winters and rather cool summers. In the interior of Jylland and the large islands the climate varies more, and the resulting periodical changes of temperature are of great importance to the growth of the trees, so many of the broadleaved trees here approximating their northern boundary. Further, the climate of the country may vary considerably from year to year, as shown by the table p. 11.

The rainfall is but small, varying from 800 mm (in parts of S. Jylland) to 420 mm (on the coasts of the Great Belt), but the relative humidity

Climatic Conditions in Denmark.

Month	Air Temperature, C°			Number of frost days	Mean humidity, °/₀	Meancloudiness, °/₀	Mean hours of sunshine	Mean precipitation, mm	Mean precipitation, days	Mean number of snow days	Mean number of stormy days
	Mean temperature	Maximum month & year average	Minimum month & year average								
Periods:	1876—1925	1876—1925	1876—1925	1876—1925	1876—1925	1876—1925	1903—1925	1876—1925	1876—1925	1874—1905	1874—1905
January	0.0	3.7	÷ 5.8	21	90	73	31	42	13	6	7
February	0.0	3.6	÷ 5.9	20	89	71	49	34	12	6	5
March	1.6	5.1	÷ 3.0	18	86	65	93	39	13	6	6
April	5.4	8.0	2.5	7	80	56	157	38	11	2	3
May	10.5	13.8	8.1	1	74	52	228	41	11	0.3	3
June	14.2	18.2	10.7	0.0	74	52	226	46	10	0.0	2
July	16.0	18.7	13.7	0.0	77	56	217	65	13	0.0	2
August	15.3	17.9	12.8	0.0	80	58	168	78	15	0.0	3
September	12.4	14.5	10.0	0.2	83	54	138	57	13	0.0	3
October	8.0	11.3	5.2	3	86	66	81	67	15	0·4	7
November	3.9	7.2	0.7	10	89	71	40	53	14	2	6
December	1.4	4.6	÷ 2.3	17	90	78	16	54	15	6	7
The Year	7.4	8.8	5.9	97	83	63	1445	614	155	29	54

Danmark, Land og Folk, 1919, gives for the various counties the mean temperature etc. in different parts of the country.

of air is great. Long periods of drought or of rainy weather may occur at any time of the year. Frost and thaw will frequently succeed each other rapidly, and yet, long periods of frost may set in, often when the ground is uncovered and unsheltered by any layer of snow. Of great importance to the growth is the frostless period, which varies considerably; in Jylland, for instance, it averages about 150—160 days, in the islands about 170—180 days, along the coasts about 200 days, and in the small islands even 230 days. On an average, the last frost occurs in the inner parts of Jylland about May 10th, in the islands on May 1st, and in Lolland-Falster and in the coastlands about April 15th—20th. Variations from year to year, too, are considerable, and especially night frost in Spring may cause great damage. Frost in Autumn often checks the maturation of the shoots, especially for trees of southern provenience.

The climate is very windy, and the direction of the wind changes frequently. The W. and SW. winds are predominating, but the E. and N. winds from countries with continental climate are of great importance, especially in Winter and Spring. Annually only 4 % of the days are calm, and the force of the wind averages 6—8 m per second (in Winter 7.5 and in Summer 6.1). During the period of growth do the cold NW. and W. winds check the growth in height, and also affecting the shape of the trees, very considerably. The gales, moreover, often cause great damage to spruce stands and beech standards; this was particularly the case in Feb. 1894 and at Christmas 1902. Glazed frost and pressure of snow also prove detrimental.

HISTORY AND LEGISLATION OF FORESTRY.

Originally the greater part of the country is supposed to have been covered with forests, but rapid colonizations would often supplant these, and in the course of centuries the rest was laid waste through grazing and reckless use of the young wood. It was an asset, on the other hand, to let the pigs root up the ground in search of mast, so much indeed that the income from that cause in 1688 constituted the basis for the registration of the forest.

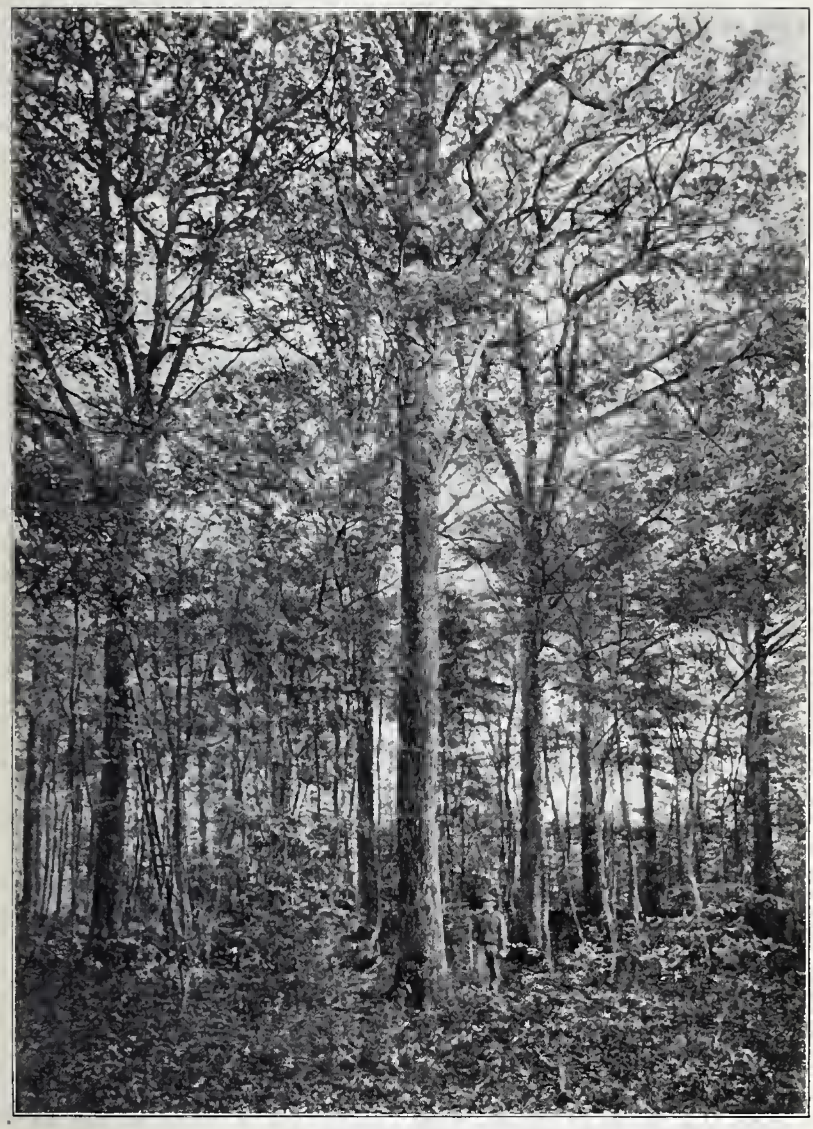
From 1670 a good many regulations were enforced to protect the public and private forests, but want of money most frequently neutralized same. — In 1762 J. G. v. Langen from Brunswick was called in aid. In the course of a few years he worked out plans for the public forests of N. Sjælland, proposed the highwood system to replace sporadic felling, and laid out plantations (abt. 1000 ha), often greatly mixed, in that way extensively introducing coniferous trees. In 1776 the work was suspended owing to lack of means. In 1781—88 the public forests were subjected to a division, and the private ones followed. The act of Sept. 27th, 1805, which is still in force, abolishes all rights to private forests, held in common, and prohibits, without proportionate regeneration, the felling and cutting of wood and in purchased areas the cutting of wood for sale for 10 years, unless sanctioned by the government. In compensation for right of pasture, the parts of the woods most scantily covered with trees were set apart and cleared, while the rest was protected and grazing forbidden.

About the year 1800 a great number of skilled Hanoverian foresters came to this country, engaged publicly and privately. Most eminent, however, was C. D. F. Reventlow (1748—1827), the Danish feudal count, who when a minister for nearly 30 years was in charge of the public forests and who, on his Lolland estates, Pederstrup and Christianssæde, carried his principles into practice, which may briefly be summarized as follows: Regular partial clearances; natural regeneration with slow transition (10—20 years) to new generations; frequent thinnings commencing early (with 2—5 years' interval); short rotation; and 4 % rate of interest on capital vested in trees. In this way the number of stems became small, and the boles short but valuable, and the yields from thinnings considerable. On the basis of measurements he worked out tables showing an average annual yield of 15 m^3 per ha for beech. In 1816 he published a small treatise, but most of his materials was not found and published till 1879. However, his ideas prevailed here and there, and now form the basis for a new system of dealing with the forests.

A School for Forestry, founded by v. Langen, lasted only a few years. In 1786 the instruction in forestry was entrusted to the two rifle corps at Helsingor and Kiel respectively. In 1808 it ceased to be entrusted to the army, but the school was continued in Kiel until 1832, when it was transferred to »Den polytekniske Læreanstalt«, and in 1863 to »Den kgl. Veterinær- og Landbohøjskole«.

For the last 50 years developments have been rapid. Periodicals and associations for forestry arose, thus in 1888 »Dansk Skovforening«, and in 1901 a regular experimental station was established. In 1911 a directorate under the Ministry of Agriculture was put in charge of all the public forests, which since 1823 had been entrusted to conservators responsible to the ministry.

Legislation. As mentioned above, the act of 1805 is still in force. The restriction, particularly, as to cuttings the first 10 years after purchase, is



Oak sample plot at Brahetrolleborg, sown 1785, registered since 1826. photo 1924.

strictly observed, and the marking of trees for felling is done by one of the inspecting foresters (see p. 54). In 1920 a commission for forest legislation was appointed, which is still sitting.

By the taxation acts of 1903 the old standard of land tax, according to which woodland generally paid half as much as arable land, was replaced by a rental tax on property at its marketable value, which from 1925 equally applies to rates. According to act of August 7th 1922 the taxes are partly to be levied on the ground value of property, the assessment of which is rather high for woodland, thus rendering taxes onerous. Assessments are to be made in 1923 and 1926, then every fifth year. Heath plantations, however, are exempt from taxation for as long as 60 years. Auction fees, too, are exceptionally high for forests. — Act of April 6th 1906 prohibits the parcelling out of consecutive tracts of woodland into parts of less than 50 ha, and those already under 100 ha are subject to no further division. — Act of Oct. 4th 1919 about converting of feoffs, entails, and family estates into private property, will probably involve changes to forestry as well. There is this restriction to the act, however, that undivided tracts of woodland are not to be parcelled out without the ministry's assent, and that only 20 % is to be sold of a wooded estate comprising more than 300 ha, the rest not to be parcelled out into less than 600 ha each. — By act of March 1st 1919 public grants have been accorded to associations for minor forestry. — Finally does the act of May 8th 1917 for the conservation of natural scenery authorize restrictions in many respects, e. g. public admission. — Act of June 30th 1922 limits the right of killing game to the landowner, and in state forests, to the king.

STATISTICS OF ACREAGE.

The official statistics of forest acreage (excepting official lands and large meadows, etc.) supply the following figures:

	ha	percentage	ha per 1000 inhabitants of total pop.	of country pop.
Islands . . .	133 856	10.0	76	170
Jylland . . .	233 479	7.9	156	218
Denmark .	367 335	8.5	112	198

Denmark is thus one of the European countries that are poorest in woodlands, although the percentage has nearly doubled the last century, in Jylland alone more than quadrupled. More extensive forest tracts are found in N. Sjælland (Grib Skov) and in N. Jylland (Rold Skov), both of which comprising abt. 60 km^2. Otherwise the woods are generally small. Percentage is highest in Bornholm (16) and in the county of Frederiksborg in NE. Sjælland (15), lowest abt. 3 % in the county of Tønder (SW. Jylland).

Ownership. Of the forest acreage, abt. 18 % is public property (including Sorø Academy), 7 % belongs to the Dune Inspectorate, 2—3 % to the Municipalities, 3 % to various Institutions, 2 % to the Danish Heath Society, and the rest is private and official property. — The public forests comprise most of the woodlands in NE. and N. Sjælland, a smaller tract in Falster, a large one in Bornholm, and the rest in Central-, W. and S. Jylland.

Apart from property belonging to the State and to the Municipalities, no less than 90 000 ha, or a little more than 1/3 of all private woods, are estates of less than 60 ha. The percentage is highest in Bornholm, E. Jylland, and Fyn, lowest in the counties of Sorø and Præstø. Of the area of private forests only 66 % in the islands and 35 % in Jylland are estates exceeding 240 ha.

Growth of trees. Area covered with trees abt. 1913, distributed according to management, percentage (A. Oppermann):

Part of the Country	Beech	Oak	Other folifers	Spruce	Pine, Larch	Mountain pine	Nurseries	Other management
Sjælland	64.1	6.7	6.4	17.8	2.5	0.7	0.1	1.7
Bornholm	9.7	2.3	13.0	61.9	10.5	0.4	0.1	2.1
Southern Islands (Lolland, Falster, Møen)	70.3	11.6	4.7	9.7	1.3	0.4	0.1	1.9
Fyn	57.0	8.9	10.5	18.8	2.4	0.4	0.1	1.9
All Islands	61.5	7.8	7.2	18.5	2.6	0.6	0.1	1.7
Jylland, wooded part	40.8	4.2	8.3	39.6	2.1	2.8	0.2	2.0
» , heaths	1.4	0.3	0.2	46.9	0.7	42.6	0.3	7.6
Dunes	0.0	0.0	0.6	0.7	0.0	98.5	0.2	0.0
Woodlands of Denmark	55.5	6.7	7.5	24.7	2.4	1.3	0.1	1.8
Whole of Denmark	41.0	5.0	5.6	26.9	2.0	16.5	0.2	2.8

Within the various parts of the country there is a good deal of variation. Thus, SW. Sjælland has 73.5 % beech, NE. Sjælland 57 %, and NW. Sjælland 53.5; on the other hand, the spruce percentage of the two latter districts are 22.9 and 24.1 respectively. Jylland has a lower beech percentage than the islands, yet E. Jylland, south of Aarhus, has 66.6 % beech. From 1881 to 1907 the beech acreage has remained unchanged (abt. 1080 km^2). The oak prevails especially in the southern islands, although in SE. Sjælland, S. Fyn and E. Jylland s. o. Aarhus, it exceeds 9 %, mostly due to young plantations. Many small oak stands, etc. are included in the beech acreage. The oak acreage 1907 was 129 km^2. Copse of hazel and other shrubs has gone down from 7120 ha in 1896 to 1744 in 1907. The acreage of coniferous trees, on the other hand, has been enlarged from 193 km² in the islands and 254 km² in Jylland to 282 and 1060 km² respectively during the period 1881—1907.

Some areas destitute of trees are statistically entered as woods, thus all plantations, even if no planting has taken place. For some large woodlands the following figures are given (including official lands, etc., left out in the above statistics):

	Percentage of total area »uncovered«		Percentage of »uncovered« area to be cultivated	
	1897	1913	1897	1913
Islands	13.7	11.4	19.1	7.9
Jylland	42.7	26.7	80.6	48.9
Denmark	28.5	19.5	64.9	37.6

Distribution according to age-classes (districts excl. new plantations) abt. 1913. High-forest (A. Oppermann). Percentage:

	Beech			Oak	Other folifers	Conifers excl. Pinus mont.	
Age	Isles	Jyll.	Denm.	Denm.	Denm.	Isles	Jyll.
0— 20	14.6	10.2	13.7	41.6	32.3	26.9	48.0
21— 40	20.0	12.1	18.4	10.7	27.6	36.1	34.9
41— 60	14.4	14.6	14.4	9.1	20.3	25.6	10.3
61— 80	12.0	12.9	12.2	10.2	12.5	7.9	6.0
81—100	17.7	14.7	17.1	13.3	5.0	2.8	0.7
101—120	15.2	10.6	14.2	7.5	0.7	0.7	0.1
121—150	4.3	12.0	5.9	3.1	0.6	0.0	0.0
150 upw.	1.8	12.9	4.1	4.5	1.0	0.0	0.0

Cultivations: Of 1000 ha cultivated area averaged for the islands 1908—12 (A. Oppermann):

Species	High-forest								Low-forest
	Beech	Oak	Alder Birch	Other folifers	Spruce	Silver fir	Pine	Other conifers	
Sowing	164	150	3	4	0	1	19	0	6
Seedlings ..	133	40	8	0	2	1	17	2	0
Transplants	58	1	55	40	129	122	6	32	7
Total pct...	36	19	7	4	13	12	4	3	2

There is a strong tendency to use seeds or seedlings instead of transplanting, which is due to a demand for a great number of plants. Thus, the planting of transplants in 1894 constituted 45 %, and in 1910 only 17 % of cultivated beech area. At the same time, great changes have taken place, especially from beech to oak, from spruce to silver fir, from white pine to Sitka spruce and Douglas fir. By 1910 the annual percentage of cultivations in the islands was 1.06 % of the wooded area, and only 8 % of the cultivations on »uncovered« lands. East- and a part of Central-Jylland correspond to the islands, while heaths and dunes present quite different proportions, thus e. g. spruce and mountain pine prevail, and transplants and seedlings are used and cultivated chiefly on lands otherwise »uncovered«.

FOREST TREES AND THEIR GROWTH.

FOLIFEROUS TREES.

Beech, »Bøg« (Fagus silvatica L.), is the chief forest tree, but the approximation to its northern boundary influences its growth. For its healthy development it requires small changes in temperature, a long frostless period, great relative humidity, and suitably damp and deep soil (Langeland, Als, and several coast districts), thus attaining a height of 30, exceptionally 35 m. Damp clay is the poorest soil (Lolland, Bregentved environs), or dry sand (Central-Jylland, parts of Grib Skov). Frequently it gives rise to raw humus. Besides night-frosts in spring, some damage to the young plants is due to the field-mouse gnawing the bark, and Phytophthora Fagi is destructive to the seedlings. Canker (Nectria) also causes some damage.

Beech stand, at Brahetrolleborg, 66 years old.
Undergrowth of maple.

Oak Common oak »Stilkeg« (Quercus robur L. = Q. pedunculata Ehrh.) and sessile oak »Vintereg« (Q. sessilis Ehr.). Sessile oak is the rarest species, especially found in Mid-Jylland and Bornholm. For some time the oak was about being ousted by the beech, which grew up in the soft shade, especially after the forest was sheltered, and oak-wood was in great demand. By 1890, however, the cultivation of oak was resumed on a large scale, especially in hard soil, which was unsuitable for beech. Middle-aged and old oak is mostly found as small stands in beech-woods. Great demands have resulted in imports, chiefly from Holland, of large quantities of acorns, which give straighter stems and more homogeneous stands (smaller dispersive power, »Spredningsevne«[1]) than Danish acorns, but, on the other hand, the plants from imported nuts are more exposed to mildew, Oïdium quercinum (first appearance in 1908), and Myxosporium; further, their annual shoots have difficulty in maturing before the autumn frosts set in.

Ash, »Ask« (Fraxinus excelsior L.), is often cultivated in small hollows of the beech-wood, but requires nutritive, damp soil, without stagnant water; only occasionally does it attain a fine growth. Nectria ditissima causes some damage.

Maple, Sycamore, »Løn«, »Ær« (Acer pseudoplatanus L.), are especially found in beech-woods and often constitute undergrowth, where intensive thinning of beech has taken place. Norway Maple, »Tandbladet Løn« (A. platanoides L.), and Field Maple, »Navr« (A. campestre L.), are of minor importance.

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[1] A term defined as follows (Haandbog i Skovbrug): Possibility of making some individuals of the stand grow faster than others, thus causing a dispersion over a large or small number of dimensions.

Common Alder, «Rødel« (Alnus glutinosa Gärtn.), is often greatly exposed to Cryptospora suffusa, but in some places, e. g. near Mariager Fiord in NE. Jylland, it forms fine wood. — White Alder, »Hvidel« (A. incana Willd), was brought into the country by v. Langen. The trees are frequently used as »nurses« for beech and oak plantations.

Common Birch, »Vortebirk« (Betula verrucosa Ehrh.), used as »nurses« and »fillers«. »Hvidbirk« (B. pubescens Ehrh.) cultivated on moors, especially in NE. Sjælland and Central- and NE. Jylland, but rarely attains a fine growth.

Hornbeam, »Avnbøg« (Carpinus betulus L.), reaches its northern boundary in this country, found mostly in the southern islands among beech, or forms undergrowth under oak, together with Hazel, »Hassel« (Corylus avellana L.), a. o. species.

Of other foliferous trees may be mentioned: Mountain Elm, »Ælm« (Ulmus scabra Mill. = U. montana With.). Lime tree, »Lind« (Tilia cordata Mill.), of rather rare occurrence, mostly amongst copsewood. Aspen, »Bævreasp« (Populus tremula L.), mostly in Central-Jylland on the border of the heath or as dwarfed shrubs amongst the heather. — Besides we find a number of Willows, »Pil« (Salix), and species of Mountain Ash, »Røn« (Sorbus), the latter chiefly in Bornholm. Holly, »Kristtorn« (Ilex aquifolium L.), may in E. Jylland form undergrowth for beech, its eastern boundary is in this country. Mistletoe, »Mistelten« (Viscum album L.), is now very rare.

CONIFEROUS TREES.

All cultivated coniferous trees are imported. Juniper, »Ene« (Juniperus communis L.), is our only indigenous species, especially in NE. Jylland

and on the heaths. Of Yew, »Taks« (Taxus baccata L.), a remnant has been found, and Common Fir, »Skovfyr«, may have persisted in some places till abt. 1800.

Spruce, »Rødgran« (Picea abies L. = P. excelsa Lk.), was introduced abt. 1760. Now it covers no less than 1/4 of the acreage of the old woodlands and large tracts of heath-land, in spite of unpropitious climate and soil in most places except parts of the islands and of Jylland (Rold Skov). The wind upsets them or, partly bursting their roots, leaves them open for the ravages of Polyporus radiciperda, so that spruce insufficiently thinned often has to be cut down at an age of 40—50 years. Economically, the proceeds are so great that, owing to the high prices even for small dimensions, it is often cultivated in soil where it does not properly belong. Other fungi and insects are comparatively innocent. Hylobius abietis, however, must be kept in check. Only in heathy parts is there any risk of forest-fires.

White Spruce, »Hvidgran« (Picea canadensis Sarg.), introduced abt. 1790, is now only used in heath and dune plantations, and as shelter-belts.

Silver Fir, »Ædelgran« (Abies alba Mill. = A. pectinata D. C.), was introduced by v. Langen. Its use became extensive when the cultivation of spruce became problematic, but there is a decline in its cultivation after the violent attacks of aphides, especially Chermes piceæ, which commenced by 1900. Old Silver Fir is of rare occurrence, found chiefly in Bornholm.

Common Fir, »Skovfyr« (Pinus silvestris L.), has been re-introduced and much used, especially on the heaths, but Lophodermium pinastri, favoured by the damp climate, has caused great damage. Now experiments are being made with Scotch and W. Norwegian firs. At Silkeborg and Tisvilde there are some quite good old stands.

Mountain Pine, »Bjærgfyr« (Pinus montana Mill.), introduced in 1798, but of no importance till the sixties when the cultivation of heaths and dunes was taken seriously in hand. Now it covers $^1/_6$ of the total wooded area of the country, which is partly due to its few requirements and partly to the fact that by way of interspersion it may help the spruce through critical periods on heathy ground.

Austrian Pine, »Østerrigsk Fyr« (Pinus laricio Poiret), was ravaged and spoiled by Lophodermium, and White Pine, »Weymouthsfyr« (P. strobus L.), by Cronartium ribicola, so that cultivation has mostly been given up.

Larch, »Lærk« (Larix decidua Mill. = L. europæa D. C.), introduced by v. LANGEN. Several fine old stands are found, but many young ones suffer considerably from Dasyscypha Willkommii; hence, of late years, L. leptolepis Gord. a. o. have been used.

Douglas Fir, »Douglasie« (Pseudotsuga Douglasii Carr.), and Sitka Spruce, »Sitkagran« (Picea sitchensis Traut. et Mey.), have of late years been gaining ground.

Older experimental plantations are found in the Langensø district (Fyn), in Linaa Vesterskov (near Silkeborg), and at Søllestedgaard (Lolland). At Charlottenlund there is a forest-botanical garden, laid out in 1838. Besides, the Experimental Service has experimental grounds in various parts of the country, and many others have been laid out by the managers of forest districts (Frijsenborg, etc.).

As enemies of the trees we must include Game, which are often plentiful on private estates. Red-deer only occur in some parts of Jylland, and fallow-deer mostly in parks. The roedeer, on the other hand, is common, and fencing is nearly always requisite for plantations of oak and silver

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spruce, sometimes also for beech. Hares, too, often cause great damage, and it is difficult to keep them out by fencing. Pheasants cause damage only on a smaller scale (in sowings).

METHODS OF TREATMENT.

Regular highwood is wholly predominating. Sporadic felling takes place mostly in small woods, and coppice occurs only in damp hollows, and is fast disappearing.

Rotation is now abt. 110—120 years for beech, 120—130 and upwards for oak, and 40—80 for spruce, according to state of health. For each section, however, rotation is greatly influenced by quality, due regard to periods of felling, and a steady yield.

Regenerations are accelerated scientifically, and standard trees are rather quickly removed. By intense work of cultivation, and great costs as well, some fine stands comprising a large stock of trees have been reared, and by careful thinning the good ones are on the increase. This method of cultivating has often been necessary wherever fencing had to be done owing to a large stock of game, but gradually attention has been drawn to the damage, both to the ground of the cultivated section itself and to that of the neighbouring stands, caused by this sudden exposure to light. These and other circumstances, e. g. high wages, have of late years in some places resulted in a return to the old Danish methods of treatment according to Reventlow's principles (see p. 14).

SYLVICULTURE.

NATURAL REGENERATION.

The seedyears for beech are very irregular in its occurrence (every 4—6. year), and this fact limits the use of natural regeneration. If the ground is good, it is only harrowed before the fall of the mast and after the old leaves have been raked off. A number of special implements have been in use, now mostly superseded by spring-harrows. At the same time tracks are marked out, not more than 80 m apart, for the removal of the assortments, sometimes also ditches are dug out, and, in case of a large stock of game, the plantations are fenced in. After the mast-fall in October the seed is harrowed down and the leaves are spread. If the ground is less propitious, a thorough preparation by ploughing, harrowing, and liming is necessary several years before regeneration. To this end two special ploughs, »Buchs Plov« and »Godskesens Plov« have been in use. The latter was especially used by H. C. ULRICH (1st Kjøb. district) in his extensive cultivations on raw humus. — During the winter following the mast-fall, about $^1/_3$ of the number of stems and of volume, varying according to ground and soil, are removed by clearance; where the soil is good and deep and where the ground slopes to the south, the smallest number is felled. In hard soil the roots of the standard trees will often be cramping the young plants; this may, to some extent, be helped by girdling, but the most effectual thing is to supplant them by »nurses«, and to cut them down in the course of 5—6 years. In deep soil the standard trees are retained as much as 10—12 years or more, longest along tracks and in north and east boundaries, where they protect against cold winds and too sudden thawing after night-frost in spring. — For other species, natural regeneration is of no importance at present, amongst other things because oak, silver spruce, common fir, and larch, but seldom occur as large old stands. Ash-trees will often regenerate freely in beech-sown areas, but usually they are planted.

SOWINGS OF BEECH AND OAK.

»Artificial« cultivations have gradually come to play an important part, either because it was desirable to adopt other species, or because the few good seedyears resulted in gathering of seed or importation of same. The demand for a homogeneous stand teeming with plants occasioned, for beech and oak, that sowing or planting of small plants replaced the large nursery plants.

Particular attention is called to the cultivations, carried on extensively, by H. P. Winge (Frijsenborg) and L. A. Hauch (Bregentved, last); they are distinguished for thorough preparation by deep digging and subsequent cleaning. The prepared strips are 40—60 cm wide, abt. 125 cm apart from centre to centre. The seed is sown in a furrow made in the middle of the levelled strip, and for beech 3—7 hl per ha is calculated, which gives $^1/_4$—$^1/_2$ mill. plants per ha (50 pct. germination), for oak 10—14 hl, which gives 150—200 thousand plants per ha (80 pct. germination). This large number of plants, however, is somewhat reduced, when plants are removed, yet Hauch insists on not less than 200 000 plants per ha. Cleaning was carried on once or twice a year by weeding the strips, partly by means of a hoe, partly with the hand, and the grass between the strips was cut with a scythe. This method of cultivation, however, is very expensive; hence, the hoe and the plough have often replaced the spade, and sowing in

18 years old oak sowing. Dutch origin.

patches has been used instead of in strips. On plains and old arable land, extensive cultivations of oak have been carried on, sowing taking place amongst rye or oat, which may be harvested without damaging the young plants. Owing to the high wages of late years, either horse-power or the scythe has been used for cleaning the cultivated strips. In beech plantations cows will be grazing under supervision as long as the plants have no young shoots; in this way the grass is kept low, the mice are deprived of their hiding-places, and the risk of night-frosts is limited. If the grazing causes no damage, the restriction of 1805 gives rise to no objections from the authorities (see p. 13).

As to clearances, these are generally effected on a somewhat larger scale than for cultivation by natural regeneration, more so for oak than for beech. The felling of beech standard trees over oak is generally finished in 3—6 years, and sometimes even »nurses« of birch and white alder are planted instead. These species or sometimes larch, and, in loose soil, mountain pine, may also be planted temporarily where e. g. spruce has been blown down, and the permanent species is then sown or planted afterwards.

PLANTINGS.

The plants are taken either from the above-mentioned strips or from special nurseries, which are often temporary, and in that case laid out for the particular regeneration. The transplanting is generally done in furrows dug out with a spade, and the distance between the rows is made large enough to allow of cleaning by horse-power. — The preparation of the soil in the area to be cultivated may consist in the digging of furrows as by sowing, or in the digging (or hoeing) of holes. In very loose soil a simple preparation of patches takes place by means of planting-drills. (As for heaths and dunes, see below). — Planting is done carefully, and the holes are made large enough for the roots to retain their natural position. — Beech plants are usually 1 or 2 years old, taken from the sown area and transplanted in »groups« of 5—6 plants in a groove made in the furrow, 0.3—0.5 m apart, or they may be pricked as single plants. In a few cases large clods with 10—15 plants are taken out and moved, but this method is very expensive. The planting of $^1/_2$ or $^2/_2$ plants is a method now rarely resorted to. — Oak. Planting is rendered difficult owing to the tap-root; nevertheless, one year old plants are sometimes used. Clod-planting is also used.

— The remaining foliferous trees are generally planted in dug-out holes, 1.3 × 1.3 m apart, as 2 or 3 years old prickled plants. — Spruce and silver fir are nearly always planted as $^2/_2$ in dug-out holes 1.3 × 1.0 m apart. Silver firs are generally planted under shelter, but spruce usually after clear-felling. — Common fir and mountain pine is generally planted $^2/_0$, and other coniferous trees as transplants. — Cleaning for furrow-plantations is the same as for sown areas. For hole-plantations, grass and weeds are simply cut down.

THINNING.

FOLIFEROUS TREES.

Already more than a century ago did Count C. D. F. Reventlow (see p. 14) and C. V. Oppermann (Brahetrolleborg 1806—57) practise careful heavy thinning, and the work was carried on especially by H. C. E. Wellendorf (Odsherred 1827—59), C. H. Schröder (Wedellsborg, etc. 1845—1906), H. C. Ulrich (1st Kjøbh. district 1862—99), Elers Koch (Brahetrolleborg 1883—1913), and K. Mørk-Hansen (Ravnholt from 1887).

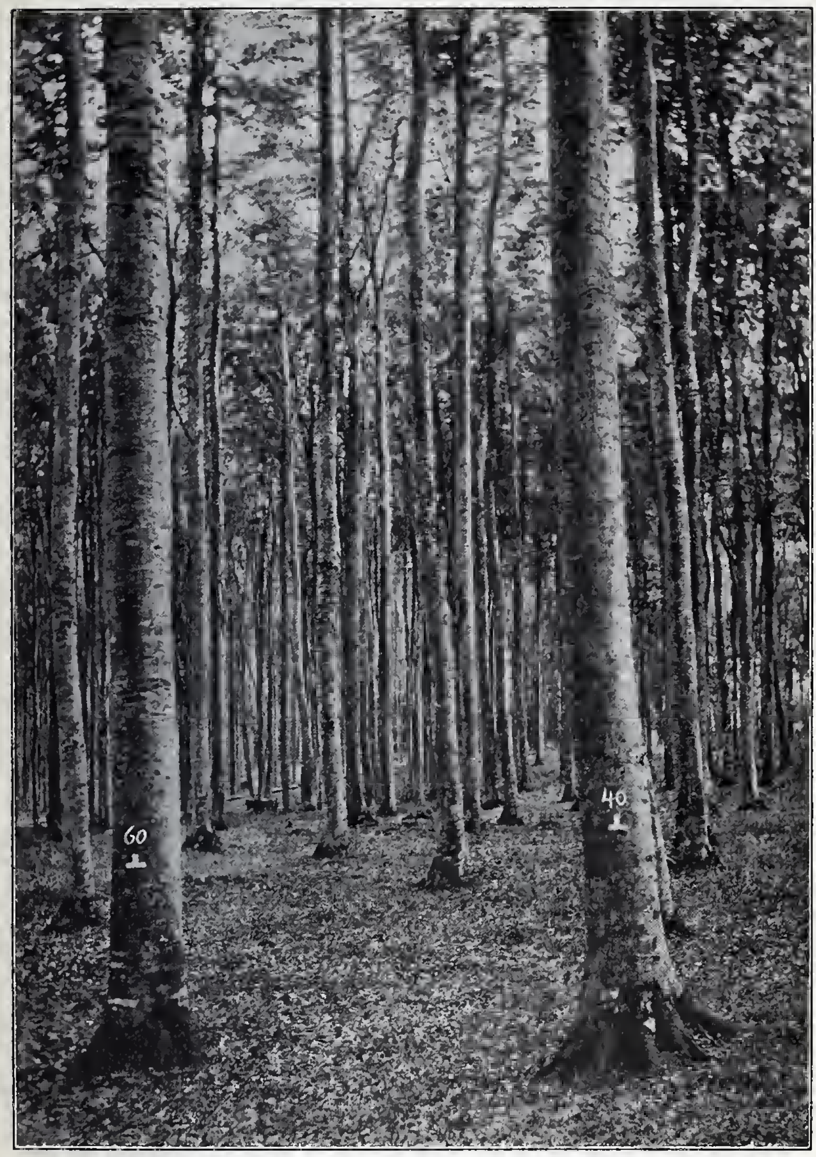
The »heavy« Danish thinning may best be characterized as »frequent«, moderate for a start, but gradually heavier without exposing the trees and the ground too suddenly to the light. In trees of younger growth it is mostly the misshapen trees, and those having »flagelliform« crowns that are removed. The dominant ones are cut down only if they are cramped for room. In some cases the suppressed trees are spared, according to C. H. Schröder's principle. They are of value to the ground, which otherwise may be exposed to draughts or growth of grass, but may prove detrimental where there is a tendency to formation of raw humus owing to accumulation of leaves.

Natural-pruning is gradually stopped when a suitable bole is formed; the length of this may vary according to growth and rotation, generally 10—15 m with an increment of a few meters after the heavy thinning has commenced. That self-pruning is stopped is partly due to the wish of obtaining a good yield, partly owing to the experience that the last piece is the most expensive to prune, — the increment pct. being strongly reduced in case of deficient thinning, — and it is always covered with a rather thin layer of wood. Frequent, intensive thinning is made paying through the high prices fetched for small assortments; besides, the forests are well provided with roads and tracks, thus rendering special arrangements superfluous, and the small districts with a sufficiently large staff makes the marking for thinning practicable.

Beech. Thinning is often commenced at an age of 15—20 years, and natural-pruning is stopped at an age of 50—60 years. The following yield-table (see p. 35) for beech in good soil in E. Denmark has been prepared by the Experimental Service to illustrate thinning and growth and is based on 4 sample plots (3 of them in Odsherred), two of which have been registered since 1852, and one from 1872.

By a comparison of this table with trees of 1st quality in Switzerland (Flury) and Prussia (Schwappach), we arrive at the following figures, according to A. Oppermann (D. F. F. IV):

Age, years	30	50	70	90	110
Stems per ha after thinning					
Denmark	2936	917	454	280	200
Switzerland I	2750	1080	660	480	400
Prussia A I	6700	2940	820	340	232
Mean volume of tree after thinning, m^3					
Denmark	0.05	0.29	0.84	1.72	2.83
Switzerland I	0.06	0.32	0.78	1.32	1.79
Prussia A I	0.02	0.09	0.43	1.22	1.99



Beech sample plot at Odsherred, 98 years old; heavy thinning.

Age, years	30	50	70	90	110
Mean volume of felled tree, m^3					
Denmark	0.02	0.18	0.63	1.48	2.43
Switzerland I	0.02	0.09	0.28	0.48	1.00
Prussia A I	—	0.06	0.18	0.83	2.38

Thus in Denmark it is chiefly from amongst the dominant trees that thinning takes place. A comparison of the heights go to prove that the Danish table comprises a growth intermediate between firsts and seconds of foreign tables. Even by the heaviest Danish thinning, more than 25 % of the stems are hardly ever cut down while young, and often only 12—18 % of the volume at one cutting; but in some districts there are only abt. 100 stems per ha at the age of 120 years.

Oak. Thinning often begins at an age of 10—12 years, but moderately during period of natural-pruning. The suppressed trees are spared according to H. C. Schröder's principle, more closely studied by L. A. Hauch (D. F. F. I and IV); they protect the ground till they are 30—40 years of age, at which time beech, bramble, hornbeam, hazel, bird cherry, a. o. are called in aid. At an age of 40—60 years so heavy thinning is carried out that the full canopy is constantly broken and nearly the total increment is removed. This procedure has been fully developed for more than a century, and a sample plot (Brahetrolleborg) has been registered since 1826 (see fig. p. 15).

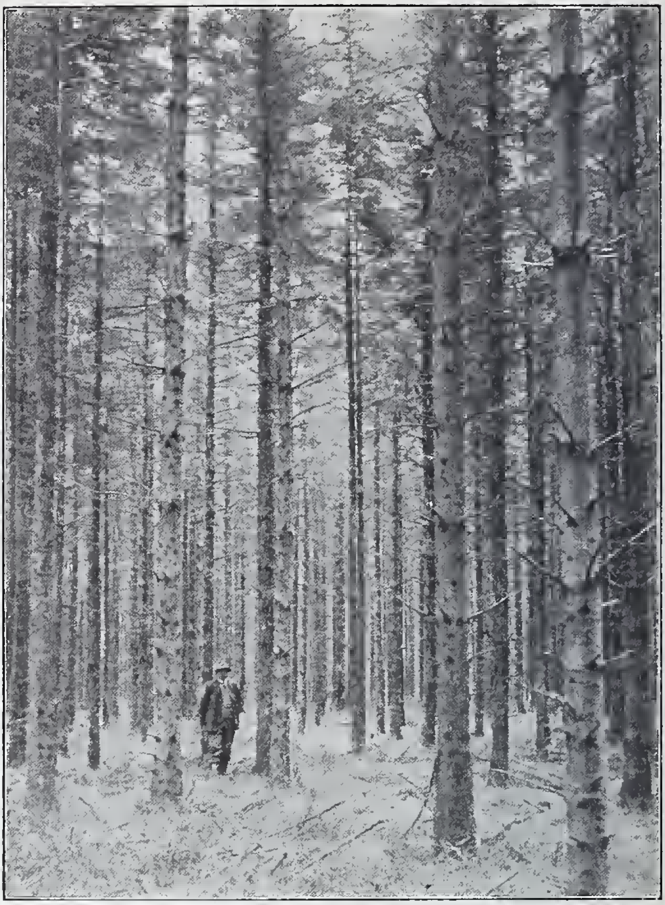
Some figures will show the reduction of stems
(A. Oppermann):

Age	30	50	70	90	110
Brahetrolleborg 1884	1321	300	130	98	92
Holsteinborg 1896	1774	407	172	98	—

Other foliferous trees are often dealt with together with surrounding beech stands. Thinning is most frequent for ash, often once every 2—3 years; hence, a quick reduction of stems.

Yield-table for Beech on good Lands in E. Denmark (A. OPPERMANN):
Heavy Thinning. 1 ha.

Age of Stand	20	23	26	30	34	39	44	50	56	63	70	78	86	95	104	114	125
After thinning:																	
Number of stems	7822	5557	4130	2936	2189	1595	1215	917	719	562	454	368	307	257	220	190	165
Diam., cm	4.67	6.06	7.48	9.40	11.34	13.77	16.18	19.04	21.85	25.04	28.14	31.53	34.76	38.21	41.46	44.81	48.22
Basal area, m^2 ...	13.42	16.04	18.17	20.39	22.12	23.75	24.99	26.12	26.95	27.68	28.24	28.73	29.13	29.47	29.63	29.97	30.13
Height, m........	7.37	8.58	9.78	11.35	12.88	14.73	16.50	18.51	20.40	22.44	24.30	26.21	27.92	29.58	30.99	32.27	33.39
Form factor	0.779	0.717	0.673	0.630	0.602	0.578	0.563	0.554	0.550	0.551	0.556	0.563	0.572	0.583	0.594	0.605	0.615
Volume, m^3	77.0	98.6	119.6	145.8	171.4	202.1	232.2	267.7	302.6	342.4	381.5	424.1	465.5	508.4	545.2	584.7	618.6
Thinning:																	
Number of stems	3178	2265	1427	1194	747	594	380	298	198	157	108	86	61	50	37	30	25
Diam., cm	2.94	3.93	4.99	6.49	8.09	10.18	12.35	15.04	17.79	20.99	24.20	27.75	31.11	34.69	37.89	40.96	43.64
Basal area, m^2 ...	2.16	2.75	2.79	3.95	3.84	4.83	4.55	5.29	4.92	5.43	4.97	5.20	4.64	4.73	4.17	3.95	3.74
Height, m........	6.12	7.39	8.64	10.29	11.89	13.82	15.66	17.76	19.73	21.85	23.78	25.76	27.52	29.23	30.66	31.96	33.07
Form factor	0.884	0.797	0.736	0.681	0.644	0.614	0.596	0.583	0.578	0.577	0.580	0.587	0.595	0.605	0.615	0.625	0.634
Volume, m^3	11.7	16.2	17.7	27.7	29.4	41.0	42.4	54.8	56.1	68.4	68.5	78.6	76.0	83.6	78.6	78.9	78.5
Annual increment																	
Diam., mm		2.9	2.9	3.0	3.0	3.1	3.2	3.3	3.3	3.4	3.4	3.4	3.3	3.2	3.0	2.9	2.6
Basal area, m^2 ...		1.79	1.64	1.54	1.39	1.29	1.16	1.07	0.96	0.88	0.79	0.71	0.63	0.56	0.48	0.43	0.35
Height, cm.......		29	30	32	32	32	31	31	29	27	25	23	21	18	15	12	10
Volume, m^3		12.6	12.9	13.5	13.8	14.3	14.5	15.1	15.2	15.5	15.4	15.1	14.7	14.0	12.8	11.8	10.2
» , pct......		13.14	10.92	9.20	7.94	6.92	6.08	5.43	4.84	4.33	3.88	3.42	3.04	2.66	2.27	1.96	1.59
Mean proceeds, m^3	4.44	5.50	6.35	7.30	8.06	8.87	9.50	10.17	10.71	11.24	11.65	12.01	12.26	12.43	12.46	12.41	12.21



Spruce stand at Frijsenborg, 39 years old;
thinned 8 times since the 20th year;
total volume of thinnings 238 m^3 pr. ha
after last thinning 290 m^3 left pr. ha.

CONIFEROUS TREES.

Spruce. There is a strong tendency to accelerated thinning, with the object of diminishing damages caused by the red-rot root-fungus so as to strengthen the trees and make them capable of resisting the wind, thus reducing the ravages

Yield-table for Spruce in Fyn. Type I. 1 ha. (O. Fabricius):

Age of stand	25	29	33	37	41	45	50	55	60	65	70
						After Thinning					
Number of stems . .	3543	2579	1961	1540	1243	1025	825	679	570	486	419
Diam., cm	10.31	12.54	14.77	17.00	19.23	21.45	24.24	27.02	29.80	32.58	35.37
Basal area, m^2	29.57	31.85	33.60	34.95	36.11	37.03	38.06	38.94	39.76	40.53	41.18
Height, m	10.51	12.51	14.45	16.30	18.06	19.70	21.59	23.29	24.80	26.12	27.25
Form factor	0.576	0.563	0.555	0.549	0.544	0.541	0.537	0.534	0.532	0.531	0.529
Stem-volume, m^3 . . .	178.9	224.6	269.5	312.7	355.0	394.4	441.2	484.4	524.8	561.9	593.9
						Thinning					
Number of stems . .	1600	1035	691	491	356	260	244	189	153	100	67
Diam., cm	6.60	8.27	10.06	11.91	13.89	15.92	18.62	21.43	24.41	27.50	30.77
Basal area, m^2	5.47	5.56	5.49	5.47	5.39	5.17	6.64	6.82	7.16	5.94	4.98
Height, m	8.66	10.22	11.76	13.54	15.72	17.81	20.19	22.21	23.90	25.34	26.53
Form factor	0.592	0.578	0.568	0.559	0.551	0.545	0.539	0.536	0.533	0.532	0.530
Stem-volume, m^3 . . .	28.1	32.9	36.7	41.4	46.7	50.2	72.3	81.2	91.3	80.0	70.0
Annually, m^3	1.1	8.2	9.2	10.35	11.7	12.55	14.5	16.2	18.3	16.0	14.0
						Annual Increment,					
Diam., mm	2.9	2.9	2.9	2.9	3.0	3.3	3.3	3.5	4.0	4.4	
Basal area, m^2	1.96	1.81	1.70	1.64	1.52	1.53	1.54	1.60	1.34	1.13	
Height, cm	34	31	30	31	31	31	29	26	24	21	
Stem-volume, m^3 . . .	19.6	20.4	21.1	22.2	22.4	23.8	24.9	26.3	23.4	20.4	
Volume, pct.	9.00	7.69	6.78	6.23	5.60	5.25	4.94	4.79	4.01	3.33	
Mean proceeds, m^3.	8.56	10.17	11.53	12.62	13.58	14.39	15.32	16.12	16.83	17.28	17.50

of gales and the bursting of the roots. Thinning often commences by the 20th year and is continued every 3—4 years. As an example of heavy thinning, the following table is referred to (Fabricius, Skovforen. Tidsskr. 1919). All volumes are stem volume. Owing to the heavy thinning we find in Fyn an extra growth of suppressed trees; at the age of 25 there were per ha 462 stems 8 m high, decreasing to 16 stems 18 m high at the age of 60; they are omitted in the calculation.

Other coniferous trees. No hard and fast rules for thinning can be laid down. The mountain pine is the most common, and thinning is carried on rather summarily.

NEW PLANTATIONS IN POOR SOIL.

HEATH PLANTATIONS.

In 1860 the heaths of N. Jylland comprised abt. 5800 km^2, or about $^1/_4$ of Jylland and $^1/_7$ of the total area of the country. Dalgas divided them into »Bakkeøer« and »Flader«, of which the former, representing the more hilly ground, go back to the first glacial period and were once covered with trees, while the flats are due to formations by the melting ice and were probably never woodlands. The plants are chiefly heather, Calluna vulgaris, in poor soil mixed with Cladina rangiferina, and in better soil with Vaccinium Vitis idaea and Empetrium nigrum. In more recent heaths, moreover, Juniperus communis, Populus tremula (as low bushes), and Sarothamnus. Under the heath-mould there is a layer of grey sand and of pan formations, sometimes as much as 30 cm deep, often impenetrable for the roots of plants, partly also for water, thus rendering planting rather difficult.

As early as 1788 did the Government start to lay out large wood plantations (Stendalgaard, Randbøl and, later on, Palsgaard), but there were great obstacles, although the soil in these places, near »the glacial border« was comparatively good. In 1816, however, no less than abt. 1300 ha had been brought under cultivation resulting in a rather good spruce-wood, while the common fir frequently succumbed to Lophodermium at an early stage. Plantings were accelerated after 1866 when »The Danish Heath Society«, was founded, amongst others by E. M. Dalgas, an officer of the engineers, who remained its director until his death in 1894. The society, whose work is not confined to Jylland, lends assistance mainly by way of skilful advice, both as to the laying out of plantations and of arranging small shelter-belts round houses and fields, and a great number of plants have been placed at disposal, either free of charge or at a low price. With the object of promoting a more rational cultivation of the heaths, moreover, marl is sought out and transported, meadows irrigated, and water-courses regulated. Many rich people laid out plantations under the supervision of the society, and a great many Ltd. companies were formed with the same object. In course of time, the society itself became the owner of plantations, often by donations. From 1885 considerable government-help was granted, upon the recommendation of the society, to those who, by a registered declaration, subject their plantations to the act of 1805. The subsidy at first amounted to $^1/_4$ of all expenses, from 1901 altered to $^1/_3$ of expenses, excepting land, buildings, and administration. Some figures will show what areas have been cultivated under the supervision of the D. H. S.: 1870: 1700 ha, 1880: 10000, 1890: 25000, 1900: 50000, 1910: 72000, and 1924: 85000. Of these, however, were at first only abt.

$^1/_2$ planted, now abt. $^3/_4$. Ultimo 1924 the society supervised 2430 plantations comprising in all 85 050 ha, of which 91 comprising abt. 20 000 ha were wholly superintended by the society, and 34 comprising 7700 ha were the property of same. 2016 plantations comprising 80 000 ha were subject to the enclosed wood regulation. At the same time the state plantations were enlarged, so that now they comprise abt. 24 000 ha. The woodlands of N. Jylland show an increase from 635 km^2 in 1860 to 2135 km^2 in 1919, a percentage from 2.7 to 8.3. Cultivation and planting have reduced the heaths of Jylland by nearly half the area in 1860. During the same period, the country population in the heath counties was nearly doubled. In the large county of Ringkjøbing, the entire population even increased from 68 000 in 1860 to 150 000 in 1924; and a typical heath town as Herning, from 870 to 9000 inhabitants.

Owing to the rapid development, work was undertaken before much experience had been gained or scientific experiments carried on; hence some technical changes have taken place. The original way of cultivating with spade and hoe proved to be inadequate, and implements drawn by horses were introduced. Of greatest importance did the Hanoverian trench-plough become (introduced 1872), because it made it possible to break through the pan and prepare the soil to a depth of 50 cm. Subsequently this has mostly been replaced by SACH's trench-plough. Investigations by P. E. MÜLLER and C. F. A. TUXEN proved that it was necessary to ventilate and prepare the heath-turf for some years before trench-ploughing, and underground ploughs, which would break the pan without turning it up, were now frequently used. In several places, especially the State plantations, 4—5 years' preparation with ploughs and harrows has consequently been resorted to, while in other places, and especially by plantations of mountain pine exclusively, only strip preparation has been used. Wherever possible, spruce is planted, often mixed with 25—33 % mountain pines, because they prove helpful in getting the spruce plants over their slack period. To this end, e. g. broom has been successfully resorted to. The difficulty lies in getting the mountain pines removed in due time. According to investigations by P. E. Müller, Fr. Weis, and Johs. Helms, the checked growth is due to deficiency in assimilable nitrogen in the acid heath-turf, but the question of how the mountain pine is conducive to growth has not yet been fully explained. Large tracts have been covered with mountain pine, and their yield of timber will be rather small. Moreover, many of these have been planted in heathlands of an inferior quality. In the better heaths, especially near the »ice-border«, good spruce-woods may result, which, at the age of 80 years, may attain a height of 20 m and a volume of 4—500 m^3 per ha, as proved by the old plantations. Of late years, many foreign coniferous trees, as well as our own oak have been tried, in order to solve the difficult problem about the next generation.

In Bornholm, the State and the Municipalities have planted large tracts of heathland, but owing to the mineral subsoil no pan formations were met with, which greatly facilitated planting. In the other parts of the country, too, large tracts of poor land have been afforested, and no obstacles to speak of have been encountered.

CHECKING OF SANDFLIGHT.

Dunes are found chiefly along the W. and N. coasts of Jylland, where they constitute one continuous belt up to 10 km wide (abt. 600 km^2) and their height is mostly 10—15 m, rarely exceeding 30 m. Dunes are also found in the county of Randers, in the isles in Kattegat, in Bornholm, and in N. Sjælland (at Rørvig, Tisvilde and Hornbæk). In the heaths of Jylland several »sands« are found, sandflight having resulted, in one way or another, from the removal of heath-turf. They are generally afforested together with the adjacent heath tracts. At Tisvilde, checking and experiments at planting were already commenced by 1730, but not till abt. 1800 was planting begun in good earnest, and now there are good stands of common fir and birch, partly also of oak and beech, the subsoil being clayey in several places. In the other dunes, the planting experiments were commenced by 1800, but met with great obstacles. In 1853 they were resumed, and in 1857 an act was passed for the expropriation of areas to be cultivated. Common fir and Austrian fir were here, as in heath areas, destroyed by Lophodermium, and only from 1856, when mountain fir was introduced, did cultivation prove more successful.

The checking of sandflight is now regulated by Act of March 29th 1867 and is in charge of a dune inspector and four dune sheriffs, all of whom are government officials; together with representatives for county and parish councils they enjoin protective and checking measures, the State defraying 1/2 of the expenses; the county, the municipality and the shareholder 1/6 each.

Formerly only marum grass (Psamma arenaria) was used, in tufts of 3—4 plants; now this is mostly used in the outmost dunes near the sea; otherwise a layer of cut down heather is used. Dune tops af some heights are left uncovered in order that the wind may level them down. When the sand is checked, planting takes place. This is done by means of a simple wedge-shaped spade, after sandflight has been checked. Mountain pine is now the predominating variety, and it is planted no nearer the sea than 5—600 m. On the dunes proper it results in scrubs only, but farther from the sea regular stands appear, interspersed with White spruce. On the heathy plains between the dunes it is possible for common fir to grow, when the proper races are chosen, and Sitka spruce, birch, oak and alder, exceptionally even beech. When the sand has drifted over clayey or chalky ground, the plantations are better. In 1890 the plantations comprised 9000 ha, 1900: 21000, and 1922: 31600, of which abt. 22000 are afforested, while abt. 3000 are to be left bare. The problem is how to grow a shelter belt along the coast and to keep it in good condition at the lowest possible expense.

FELLING AND SORTING.

The yield of wood is on the increase, and very considerably, which will appear from the following figures for large woodlands (A. Oppermann). — Cf. table of age-classes p. 19.

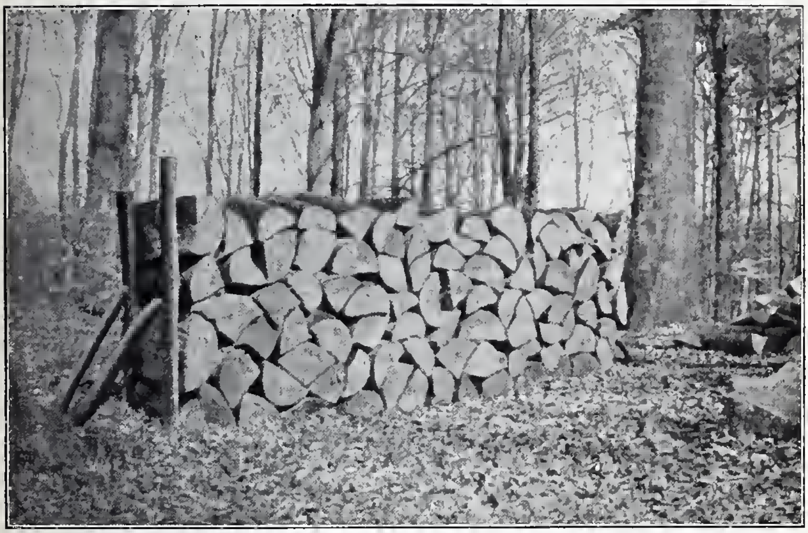
Part of country	Annual yields m³ per ha wooded area 1878	1894	1906	1910
Sjælland	5.68	5.16	5.82	6.84
Bornholm	4.41	3.08	5.14	3.87
Southern Islands	5.90	6.33	7.92	8.84
Fyn	5.80	7.40	7.14	8.17
All Islands	5.70	5.54	6.33	7.22
Jylland, woody parts	4.37	4.20	3.92	5.41

Total fall of trees is supposed to average 1.3 million m³, a quantity liable to increase in proportion to the improvements of the stands. Statistics from 1923 for abt. 34 % of the wooded acreage report on all species an average of 239 m³ per ha wooded area in the islands, distributed as follows: 71 % beech, 8 % oak, 4 % other foliferous trees, and 17 % coniferous trees. In Jylland, mainly woody country, the figures were abt. 177 m^3 per ha. Statistics covering the exact growing stock of the whole country are still wanting owing to deficient knowledge about small private woods.

For 13 State forests, in a normal state of cultivation (see p. 50), about 19000 wooded ha, the aggregate growing stock was planned to average 265 m^2 per ha (218—312). The corresponding fall for the years 1911—16, before the effects of the war were being felt, averaged 66265 m^3 mature fall and 80025 m^3 thinning, i. e. an average of 7.7 m^3 per ha or an annual yield-percentage of 2.9. During the last 5 years mature fall has annually averaged 44600 m^3 and thinning 80100 m^3 (6 m^3 per ha yearly).

Felling is always done by the authorities of the particular districts, who also sort the wood before it is offered for sale. Further preparation of the wood in the forest is undertaken on a small scale only (1.5 % of the felled and assorted yield in 1912), and consists in the cutting of timber and sawing of laths.

The assortment is now, after the metric system has been introduced, almost uniform. It is done by the forest labourers, under supervision. — Hard-wood. Clean stems are laid aside for timber as »Kævler«, generally exceeding 15 cm in diam. at the top end, and measured in m^3. Shorter clean pieces of more than 15 cm in diam. are sorted out as »Snitgavn« and, split or unsplit, piled up and measured in »Rummeter«, rm. The rest is sorted and piled, according to quality, for beech into »Klov« or »Knuder«, and for other foliferous trees into fire-wood. Wood of 10—15 cm and 3—10 cm in diam. is usually piled in rm as »Fagot« and »Knippel« respectively, and brushwood under 3 cm is then left. Sometimes, however, »Kvasbunker« of fire-wood under 15 cm are piled, and in that case nothing is left Of oak, ash, etc., wood of 15—30 cm in diam., containing some timber, is often piled in »Klodsbunker«, and of oaks, fencing poles, either split or unsplit, are sorted out. — Soft-wood. The stems are laid aside in full lengths as beams or rafters according to size, or in shortened lengths as »Savklodse«, and measured by the piece. If 1 m from the bottom end they are less than 15 cm in diam., they are called »Baand« (12—15 cm), »Lægter« (7—12), and »Stager« (less than 7 cm). They are laid in piles of certain volumes. Sometimes »Snitgavn« and fire-wood are sorted out and piled in rm. In piles are also laid top ends and unlopped stems of mountain pine as »Udhug«. Fencing poles, as in the case of oak. Sometimes »Ros«, i. e. dry or partly damaged wood in long piles, is laid aside.



2 »Rummeter Snitgavn« of beech.

Measuring and dimensions of piles. Measurements of stems are taken by gauging the diameter crosswise at the middle, and are read off in cm (under 30 cm, however, in $^1/_2$ cm). The length is measured in dcm, $^1/_2$ waste cut being deducted. The volume is figured out in $^1/_{100}$ m^3, the length being multiplied by the transverse cut at the middle. Stems of hard-wood trees exceeding 8 m, or stems suddenly changing in thickness, are measured as two or more parts. The bark is always included in the measurements for all species of wood. — »Rummeter«, rm, are piles with a cubic content of 1 m^3. To facilitate transportation, usually 2 of these are put together. The dimensions of the piles may vary according to use. For beech exceeding 15 cm the length of the pieces is usually 62.5 cm (plus 1 cm extra for oblique cuts), being the most suitable for staves, and the other dimensions are then 1.6 × 1.03 m, the 3 cm extra being accorded for the height of the piles. »Fagot« and »Knippel« are generally piled 1.0 × 1.0 × 1.03 m. Brushwood of hard-wood trees is piled in 8 rm, »Klodsbunker« and »Ros« in 3 rm.

The timber percentage is on the increase owing to the improved stands and the more careful sorting. In 1912 the various parts of the country averaged 25—32 % for beech, 40—60 for oak, 16—32 for other hard-wood trees, and 70—84 for soft-wood trees (excluding plantations). It must in this connection be borne in mind that the figures represent the average of the entire yield, of which more than half is due to thinnings.

MARKET CONDITIONS AND UTILIZATION OF WOOD.

The sale of the wood is a no less complicated affair than the sorting. Large quantities of timber may be sold to the various saw-mills, but fire-wood and timber for building purposes are often sold direct to the consumers, either at auctions, which are frequently held at the different places in the forest itself, or more privately at fixed prices.

The following table shows how the wood has been disposed of in forest districts abt. 1912 (A. OPPERMANN):

For the Islands: Sold to.

Species	Free of charge, allowances, etc., %	The neighbourhood		Outside the neighbourhood	
		At auctions, %	Privately, %	At auctions, %	Privately, %
Beech	7.5	53.6	18.6	1.1	19.2
Oak	3.5	45.6	23.2	1.3	26.4
Other folifers	2.3	66.9	19.6	0.8	10.4
Conifers	3.2	43.0	39.3	0.9	13.6
Total	5.7	52.1	23.4	1.4	17.4

In the old woody parts of Jylland the figures for »outside the neighbourhood« are considerably larger (Beech 32 %, Conifers 44 %).

Transportation is difficult owing to the mild winters, but the forests are traversed by good roads, the main ones generally being macadamized, and there are usually tracks at most 80 m apart. Horsepower is used almost exclusively in the forest, and 2 rm or a pile of brushwood is a convenient load for two horses. Transport-autos are used mostly on the high-roads. Most of the wood for the neighbourhood is transported home by the buyer, while the seller usually delivers the wood that is to go farther away, at railway station or sea-port.

The principal roads as well as the railways are usually quite conveniently accessible from the forests. In April 1924 the country had abt. 2400 km State railways, 2600 km private railways, 7600 km high-roads (mostly macadamized), and more than 40 000 km by-roads (frequently prepared with broken stones). This makes 116 km railway, 177 km high-roads and abt. 950 km by-roads per 1000 km^2. Only Belgium, Switzerland, Great Britain and Germany have more km railway, in porportion to area, than Denmark. Apart from a very few places in the heathy parts, there is hardly anywhere more than 10 km to the nearest railway station. Sailship navigation, moreover, is of no small importance to coast forests.

The prices have varied considerably of late years, and so no fixed rules can be laid down; but, owing to a rather brisk demand, they have been comparatively high. Fire-wood of beech, for instance, has frequently fetched a price nearly as high as that of »Snitgavn«. — »The Sales Committee for the Danish Forest Society« is trying by negotiations with wood-works to fix prices for the principal materials and to procure joint bids for large supplies, which a single district is unable to furnish. The country is divided into 9 »Sales Districts«, whose presidents constitute the Sales Committee.

The further preparation of the wood is mostly done by the many small saw-mills near the forests, in some cases owned by the district.

The different purposes to which the various species of wood are put, are mainly the following:

Beech. The manufacture of staves for butter-casks consumed, before the war, abt. 60 000 m^3, or half the sale of »Snitgavn«; it is mostly the thin and clean timber that is used in this way. The wooden-shoe factories consume the heavier »Snitgavn« and a good deal of »Kævler«, materials less clean, before the war using abt. 45 000 m^3, chiefly beech. Further, beech is used for planks (ship-building, furniture, etc), fellies, etc. It has also been tried for railway-sleepers, but the prices are usually too high. — Oak. Before and especially during the war, it was used considerably for ship-building purposes. Moreover, oak is chiefly used for planks, mooring dolphins, and for building purposes. Fence poles is a large item. The bark is now but rarely used for tanning purposes. — Other hard-wood. Supplies varying and rather small. Ash is mainly used for implements and carriages. — Spruce is chiefly used as building and fencing materials (small quantities only are sawn into boards); further, as poles for telephone, etc., for harbour works, seines, and submarine structures; moreover, for packing-cases (egg- und herring-boxes) and for wood-wool. Small quantities are turned into wood-pulp, but the prices are generally too high. — Other soft-wood. Larch, especially for submarine purposes, or sawn into planks and boards. A little mountain pine is burned into charcoal by the D. H. S., but its chief use is for fencing-poles and fire-wood.

Consumption of wood in the whole country. The forest very nearly supplies the consumption of beech. But timber of oak and other hard-wood is imported from other countries, birch-wood and fire-wood (waste products) from Sweden. The fuel value produced in the country (including fire-wood from saw-mills), before the war a total of abt. $^2/_3$ mill. m^3, would correspond to 180000 tons of coal, or abt. $^1/_3$ of the entire household consumption of coal and coke. — But of wood of conifers, the country is at present capable of furnishing only abt. $^1/_5$ of the consumption; in the course of a decennium, however, the production will probably be doubled. The materials are chiefly imported from Sweden and Finland.

RECEIPTS AND EXPENDITURES OF THE FORESTS.

From 1921 annual statistics are prepared by the Forest Society. — For 13 State forest districts.

normally stocked, the following annual averages are submitted (see p. 44):

	1911—15	1915—17	1917—18	1918—19	1919—21	1921—22	1922—23	1923—24
Yield m^3 per ha wooded area	7.5	8.4	21.4	8.8	7.1	5.0	6.3	7.3
Gross proceeds, 1000 Kr.	1145	1728	5128	5259	3793	2331	2450	2935
Expenditures — —	595	737	1684	1701	2090	1968	1616	1559
Net profit per ha productive area, Kr.	26	48	167	172	83	18	40	67

The normal distribution of the expenditures is as follows: Felling and transportation abt. 30 %; culturing and nursing 12—16 %; roads, water courses, preservative measures, etc. 6—8 %; buildings 7—8 %; management of district 20—22 %; sales 3—6 %; duties 15 %.

The state forests pay no taxes; hence the private woods are here at a disadvantage. For all woods in the islands, the taxes in 1922—23 averaged 18 % of the total expenses, or 1.2 % of the registered value. Felling was normal for the year in question, i. e. abt. 7 m^3 averagely per ha; the price averaged, for all assortments, 22 Kr. per m^3, of which 8 Kr. were net proceeds.

The registered values of the forests specially taxed (256000 ha) amounted in 1920 to abt. 171 million Kr. (118 millions for the islands), the aggregate amount for all landed property being 6551 mill. Kr. In Fyn, where the most valuable forests are to be found, the estimates rose from an average of 833 Kr. per ha in 1904 to 1310 Kr. in 1920. In Sjælland, the year 1920 averaged 1047 Kr., and the southern islands 1230, all the islands 1074 Kr. per ha.; while Jylland averaged only 335 Kr. owing to the heath plantations, sometimes only valued 100—150 Kr. per ha. For most counties the value of forest ground was estimated at 40—50 % of the total registered value.

LABOUR CONDITIONS.

All labourers live independently in houses, either their own or belonging to the districts. In the case of the latter, they frequently take their part in looking after the forests. The short distances enable them to live at home. A labourer's house generally consists of 2—3 good rooms and a kitchen; moreover, there is usually a garden and sometimes a small plot of ground to the house. Even the regular forest labourers hardly ever work more than 200 days a year in the forest, the remaining time being given to agricultural work (harvesting), etc. In winter there are generally labourers enough, at other times (e. g. in the culture season) it is difficult to get men. Women are sometimes employed for weeding plantations and nurseries, but of late years all kinds of outdoor work is but little cared for.

Nowadays the wages are most frequently fixed by arrangements between the respective unions. Most work is done as piece-work, but planting is generally done on daily wages. The usual number of working hours is 8.

Number of days' work per 1000 ha (incl. uncovered areas) was in 1912 for districts excluding plantations (A. Oppermann):

Dec.-Febr.	Mar-May	June-Aug.	Sept.-Nov.	per year
2249	1630	824	1182	5885

For the islands: 6—7000 a year; for Jylland: abt. 4800.

Of the many social Acts of Parliament, the following deserve special attention: Accident

Insurance (Act of $^{28}/_{6}$ 1920) is now obligatory, but the labourers are supposed to be in sick-clubs and from same to receive daily pay for the first 13 weeks after an accident. Later on they are to receive $^{2}/_{3}$ of their daily wages (maximum 6 Kr., minimum 1 Kr.), by way of compensation, for nine months at most. Maximum pay for full invalidity is 24000 Kr. and for death 12000 Kr., varying in proportion to wages received before accident. The insurance is paid by the employer. — The invalid's annuity ($^{6}/_{5}$ 1921) is paid for invalidity whether constitutional or incurred, amounting as a rule to 800 Kr., but reduced in case of pensions, compensations for accident, etc. The annuity, however, is to be applied for before the age of 62. The expenses are defrayed, partly by the labourers themselves (through their sick-clubs), partly by the employers, and partly by the State and the particular municipality. — The Unemployment Act ($^{4}/_{3}$ 1924) imposes upon the private employer a certain contribution to the Government's fund for the unemployed (in forestry now 2 Kr. a year per labourer). Support is granted only in case of extraordinary spells of unemployment, the ordinary slack periods being met by the labourers themselves through their unions. — The Sick-club Act ($^{20}/_{6}$ 1921). Considerable Government-help is granted to the labouring classes through their sick-clubs. — Old-age pensions ($^{7}/_{8}$ 1922), payable by the State and the municipalities, is an allowance to which any one is entitled at his or her 65th year; it varies in proportion to income.

In great labour conflicts between the various organizations, differences are settled, if possible, by the aid of official conciliators. In case of judicial conflicts about agreements, however, the court of arbitration, established by the Government, is resorted to for a final verdict.

MANAGEMENT.

The State Forests are under the Ministry of Agriculture, to which the Directorate of the State Forests is directly responsible in accordance with the instructions and regulations of $^{24}/_{5}$ 1924. Two »Skovridere« and two assistants, are attached to the Directorate.

Each of the districts is under a »Skovrider« (superintendent), who is responsible for the management of his district. Under him are »Skovfogder« (rangers), who superintend the practical part of the work, assisted by »Skovløbere« (sub-rangers) and »Skovarbejdere« (forest-labourers).

At present the whole staff consists of: 1 director of the State forests, 30 superintendents, 1 working-plan officer and 10 assistants, all of whom are graduate foresters. Moreover ca. 100 rangers. The age-limit is 70 years.

Sorø Academy's Forests range under the Ministry of Education, and are managed by an inspector-general (at present the forest director) 2 superintendents, and 11 rangers.

The Dune Inspectorate's plantations range under the Ministry of Agriculture, and are managed by the dune-inspector and 2 chief planters (graduate foresters), and several planters.

The Danish Heath Society is managed by a board of directors and a committee, having its chief office in Viborg, aided by a commissioned expert. The plantations range under superintendents, assistants, and planters.

The private Forests. Large districts are usually managed by superintendents, who are graduate foresters and sometimes land-agents as well; under them there are rangers, etc.

The small woods are often united (cf. p. 16), and engage the services of a skilful adviser.

Inspection of private forests by the Government (see p. 16) ranges under the Ministry of Agriculture, assisted by 14 superintendents, who besides are in charge of their districts, and, for the enclosed heath plantations, by the Heath Society.

The shooting of game in the State forests is in charge of a royal Master of the Game together with the superintendents, and the right of killing game belongs to the King, but the game itself goes to the public revenue.

The sizes of the districts may best illustrate the intensity of Silviculture.

Wooded districts (D. H. S. and the Down Inspectorate excepted) managed by graduate foresters:

Size of forest district	The State and Sorø Academy 1921						Private districts 1918	
	Sjælland, Falster		Jylland (woody parts), Bornholm		Heath, entirely or in part			
	Number	ha	Number	ha	Number	ha	Number	ha
Under 1000 ha	1	701	-	—	1	970	27	16 190
1000—1500 —	6	8178	1	1326	-	—	12	15 198
1500—2000 —	5	8664	4	7143	-	—	10	17 031
2000—2500 —	2	4401	-	—	-	—	2	4 257
2500—3000 —	2	5521	1	2849	-	—	3	8 245
over 3000 —	-	—	1	3370	6	26 394	1	3 663

In 13 of the smaller private districts, the superintendents was also land-agent or the like. The work of inspection and advice not being included in the above table, a larger area is under the supervision of graduate foresters than here indicated.

WORKING PLANS.

Many districts, both public and private, have had definite working plans to go by for more than a century; but the conditions are changing. Now the superintendents exert the chief influence on the plan, in the private forests often laying their own plans. In the State forests does a revision take place every 15th year; in the private forests, generally every 10th or 20th year.

Forest maps. There are excellent maps, 1 : 4000, based on polygonal measurements, of most forests, and from these hand-maps are made, 1 : 8000, often lithographically.

Compartments of middle size, good grounds, are now mostly abt. 5 ha, but their maximum may reach 10—15 ha. Their sites are determined by some real unit, one of the principal trees generally prodominating, so that, in case of an interspersion, other trees may be contemporary in their rotation.

As a rule, the total volume of wood is measured in this way that all stands of hard-wood trees over 60—70 years and coniferous trees over 50 years are measured by the stem, breast-high, while the height is measured on a certain percentage. Sometimes H. Prytz's »Dobbeltklupning« is resorted to; it is based on the principle that both diameter and height describe exponential graphs. In younger stands, the volume is usually measured by means of a number of circular sample plots.

The plan of cutting is divided into 1) a plan of mature fall and 2) a plan of thinnings, for the respective periods to come (10, 15, 20 years). How large the felling is to be for each year is left to the judgment of the superintendent in each case, and the plan of thinnings is not obligatory.

Together with the working plan, a thorough description of each of the compartments and their stands is often worked out, sometimes accompanied with detail relating to the history, privileges, fencing, etc., followed by statistics of Silviculture, of the particular district.

EDUCATION.

The higher education for foresters was commenced 1786, and is now given at »Den kgl. Veterinær- og Landbohøjskole« in Kjøbenhavn. There are 2 professors and 1 assistant for the silvicultural subjects proper, and 10 professors and 5 lecturers in other subjects. Instruction is supplemented by laboratorial collections and a large library (with a general loan department).

Admission is free and instruction gratuitous. Most pupils have passed a matriculation exam. The studies are carried on partly in 2 forest districts (1 year in each), partly at the school, and takes at least 5½ years.

Preparation for the first part takes 18 months, and comprises mathematics, fundamental sciences (physics and meteorology, chemistry, geology, botany — incl. microbiology and heredity —, and zoology), forestal botany, and drawing. — Second part of the exam comprises the particular silvicultural subjects; moreover, pathology, forestal zoology, social economics, book-keeping, rural jurisprudence, surveying, and knowledge of soils. The preparatory studies take 2 years and are supplemented by excursions, either for a single day now and then, or for a week in the autumn to some more distant forests, and practise in the laying of plans, gauging, and surveying. — The third part of the exam, finally, is of a practical nature, and takes place in the forest only.

Of the two years in the districts, one is to be before the first part, and the next between the second and third parts. The districts are to be of at least 500 ha wooded area and under the management of a graduate forester. Usually, one year is spent in a private district, the other in a public one, as far as possible of varying character. The first year the student is to take part in the various kinds of work, learn how to mark and keep accounts, and gain a general knowledge of forestry. The second year the student is to assist the superintendent, and to work out his own examination papers in surveying and the laying of a working plan. Shooting is no subject for examination, but the student is required to take part in the shooting that may happen to take place during his years' apprenticeship in the districts.

On an average, 6 (2—11) men annually pass the examination. It has become a practise for the State to employ only graduates that have passed with a 1st degree, and generally but 1 or 2 of each batch.

Instruction of Rangers. From 1906 an examination for rangers has been held by an commission appointed by the Ministry of Agriculture. From 1922, the pupil is to pass a preparatory examination in Danish, arithmetic, surveying, and general knowledge of plants and soils. This instruction is obtained by a 6 months' course at an agricultural school. After that, the instruction proper takes place in the course of 3 years, in two districts of at least 400 and 600 ha, and at least one year in each. The main purpose is to train the pupil for practical work in the forest and teach him how to mark trees for thinning and the keeping of accounts. His instruction is based on a text-book by the commission, the superintendent acting as instructor. The examination consists partly in the performance of some practical work, and is partly of a theoretical kind based on the text-book. On an average, 24 pupils a year have passed this examination.

EXPERIMENT SERVICE.

The Experimental Forestry Service was inaugurated in 1901; a number of sample plots, however, had been registered since 1852, and one even from 1826. It ranges direct under the Ministry of Agriculture and is managed by the director together with the commission for experimental forestry which, besides the director, who is the president and in charge of the experiments, consists of 2 representatives for the government and 2 for private forestry, together with 1 representative for the educational section. The commission publishes reports under the title »Det forstlige Forsøgsvæsen i Danmark«, edited by the director. Nearly 9 vols. (of 400 pp. each) have been issued, comprising amongst other things the following subjects: Measurements of sample plots (yield-tables for beech (3), oak, and spruce on heaths); experiments on gauging of trees; thinnings of beech and oak; heredity and provenience; forest and heath soils; plantations in raw humus and heathy soil; preservation of seed; nursery experiments; experiments on foreign species in woods and heaths; damages by late night frosts and by fungi; timber at different altitudes, and its further preparation; besides some lengthier articles on common fir and larch; for further particulars see reports, especially vol. V.

Since its establishment, the Experimental Service has been considerably enlarged. Thus in 1911 it acquired a plot of 5$^1/_2$ ha for a nursery at »Egelund« near Hillerød. In 1917 the director, Professor A. Oppermann, gave up his work as a teacher of forestry to devote all his time to the Service. The year 1919 saw the Service in possession of its own buildings, to which belongs a plot of abt. 5 ha, situated at Springforbi, abt. 13 km north of København. Besides the director, the regular staff consists of a chief laboratory assistant, a graduate forester, and a steward.

OTHER INSTITUTIONS.

The Government Seed Control, instituted on private initiative in 1871, taken over by the Government in 1891, is in charge of a commission appointed by the Ministry of Agriculture. At fixed rates, it examines the genuineness, cleanness, and germinating power of the seed. Large quantities of the seed of trees have been examined, thus rendering a real estimation possible.

The Geological Survey of Denmark, instituted 1888, carries on geological investigations and charting of the country, issuing its results in the »Danmarks Geologiske Undersøgelse« publications.

The Statistical Department provides statistics, publishing same either in »Statistiske Meddelelser« and »Statistisk Tabelværk« or in »Statistisk Aarbog«.

The Meteorological Institute published daily, monthly, and annual surveys from 160 Danish climatological stations, and 285 stations at which precipitation is measured.

ASSOCIATIONS.

The Danish Forest Society, »Dansk Skovforening« (established 1888), has for its object the promotion of forestry and related branches. In 1919 the society's sphere of activity was considerably enlarged, the co-operative forest sales districts being transferred into a trade commission under the auspices of the society (see p. 48), and a permanent secretariate was established. From 1916 the society publishes a quarterly periodical, »Dansk Skovforenings Tidsskrift«, and from 1919 a fortnightly, »Fra Skoven og Træmarkedet«. On becoming a member, the proprietor of a wood pays a subscription of 25 Øre annually per 1000 Kr. estimated value of lands. Meetings and excursions are held now and then, and every 6th year a general meeting. — In 1921 was established, for a period of 10 years, »Dansk Skovforenings Gødningsforsøg«, which, under the direction of a special committee, has for its object the examination of the soil in forests and the result of liming and manuring in forest, nursery, and heath. The means are raised by private subscriptions, and the government grants an equal amount.

The Association of Danish graduate Foresters, »Danske Forstkandidaters Forening« (instituted 1897 under the style of »Forstlig Diskussionsforening«) holds meetings and discusses technical subjects, and in general attends to the interests of the profession. The Danish Forest Society's periodical is the organ of this association as well.

The Danish Heath Society, see pp. 39 and 53.

For other associations see »Danske Skovdistrikter og deres Bestyrelse 1924« and the list of addresses p. 4.

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